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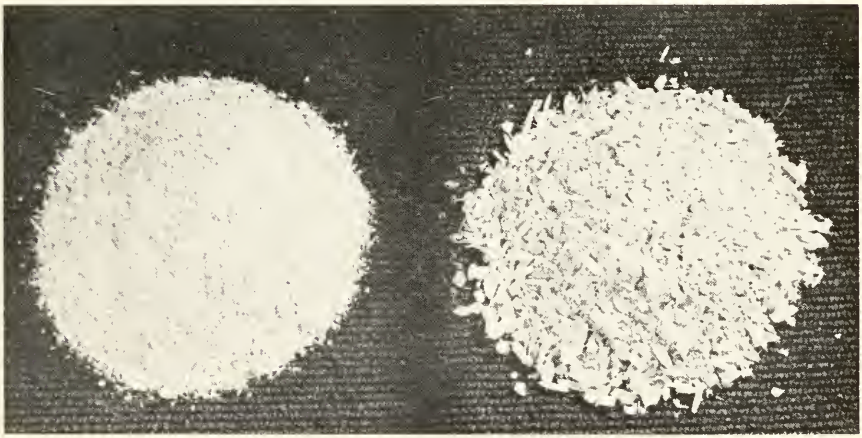

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Introduction

THE TREND in dairy cattle feeding during the past several years has been toward the use of coarse textured concentrate feeds and away from the conventional "fine" type mixtures. There has been considerable discussion among both dairymen and feedmen about the advantages of the coarse textured concentrate feeds. Many of these people have claimed that the coarse feeds are more palatable, can be consumed in greater quantities, and consequently result in greater milk production than comparable ground feeds. As a result of these claims many dairy farmers were convinced that they could afford to pay at least $2.00 per ton extra for such feeds. Economy-minded dairymen, feedmen, and research workers, however, questioned this practice. They contended that two of the most important considerations determining the nutritive value of a feed — digestibility and utilization of its ingredients — had been ignored almost completely. Because the cost of concentrates is one of the largest single expense items to a dairy farmer (approximately 22 per cent of value of milk sold in New Hampshire) and because practically no experimental evidence could be found in the literature to support the sales promotion claims, it was deemed desirable to obtain definite information on the relative nutritive value of coarse and fine textured concentrate feeds. Later, when it was found that the popular coarse feeds were less digestible than fine ones, it also was decided to find out if there were any ingredients that could be used in concentrate mixtures in the coarse form without decreasing their nutritive value.

Review of Literature

Literature dealing with the relative nutritive value of coarse and fine textured concentrate feeds for dairy cattle is very scarce. Most of the studies reported in the literature dealt with the effect of fineness of grinding on milk production. Bohstedt and co-workers (2) conducted feeding trials to determine the feeding values of corn and barley for pigs and of barley for dairy cattle when these grains were ground to varying degrees of fineness. They concluded that barley fed to dairy cows needed to be ground to a granular condition rather than to a fine meal.

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Wilbur (12) found that dairy cows utilize ground corn and oats more efficiently and economically than whole corn and oats. These two grains when ground medium fine produced more milk and fat per 100 pounds of grain fed than pulverized or coarsely ground grain. Darnell and Copeland (6) found that when corn, oats, milo, and barley in the ground state were fed to dairy cows, they were consumed in larger quantities than when fed whole. Greater milk production was obtained in all the experiments when ground grains were fed. Wallis and Olson (10) studied the effect of fineness of grinding on corn and oats. They concluded that nothing was gained by fine grinding and that it made little difference whether the grain was coarse or fine. The medium grinding of grain, which was just sufficient to break up the kernels into several portions, was considered to be the best practice. They also found that more benefits were derived from grinding corn than from grinding oats.

Olson (8) concluded from two feeding trials that the coarsely ground grain was equal or superior to finely ground grain. Ward (11) found in palatability, milk, and butterfat production trials with dairy cows that the cows showed slight preference for the coarse feed but the fine feed gave slightly more milk and butterfat. He concluded that conventional rations were as satisfactory as the coarse but due to the price difference the conventional fine feeds were much more economical.

Preliminary reports on most of the studies summarized here were presented in mimeographed form (3), (4), (7).

Experimental

This investigation was carried out in four different experiments. The nature and time of each is given below. The digestion and utilization studies were carried out in the Metabolism Laboratory of the Department of Dairy Husbandry according to procedures as given by Benedict et al. (1); Colovos et al. (5); and Ritzman and Benedict (9). The feeding experiment was carried out at the Nutrition Research Barn of the Department of Dairy Husbandry.

Digestion and Utilization Experiment 1951

A coarse-textured concentrate mixture and a medium finely-ground mixture of similar composition were compared in eight complete nutritional balance studies with four purebred dairy heifers. These heifers weighed between 540 and 600 lbs. at the beginning of the experiment and included two Guernsey, one Jersey, and one Ayrshire. Each animal was fed a daily ration of 6 lbs. of chopped hay plus 8 lbs. of ground or coarse-textured feed on all balances. The experiment was planned so that the two feeds could be compared when fed to each animal. The concentrates used were obtained from a local feed manufacturer in the form of a coarse-textured mixture containing 700 lbs. cracked corn, 600 lbs. crimped oats, 300 lbs. wheat bran, 100 lbs. pea-size soybean oil meal, 200 lbs. brewers' grains, 40 lbs. pea-size linseed oil meal, 20 lbs. iodized salt, 20 lbs. steamed bone meal, and 20 lbs. pulverized limestone supplemented with cobalt and manganese. The ground feed was prepared by grinding in a hammer mill fitted with a 3/32-inch screen 100 lb. bags of the coarse-textured feed selected at random. It was only slightly finer in texture than the so-called "fine feeds" sold throughout the New England area. The hay used was from a lot of field-cured, prebloom

timothy which had been fed as the sole ration in previous nitrogen and energy balance experiments.

The schedule of the balance experiments was as follows:

Heifer number	Breed	1st Balance	2nd Balance
11	Ayrshire	Ground feed	Coarse feed
14	Guernsey	Ground feed	Coarse feed
15	Jersey	Coarse feed	Ground feed
16	Guernsey	Coarse feed	Ground feed

Digestion and Utilization Experiment 1952-53

Because of questions raised by the preliminary report of the digestion work carried out in 1951 with heifers, the experiment was repeated on an expanded basis using four mature Guernsey cows, one of which was in lactation. Very coarse-textured and pelleted feeds were included in this experiment in addition to coarse and fine-textured feeds. These four concentrate mixtures, the formulae of which are given in Table 1, represented the principal types of texture found in dairy feeds sold in the New England area and were formulated by representatives of two of the larger feed manufacturers of this area.

Table 1. Formulae of Concentrate Mixtures

Ingredients	Fine	Coarse	Very Coarse	Pellets
	%	%	%	%
Ground flaked corn	10	10		10
Hominy feed	10	10	10	10
Ground crimped oats	22		7	22
Ground flaked barley	5			5
Wheat bran	10		10	10
Corn gluten feed	10	10	10	10
Distillers' grains	10	7	10	10
Linseed meal	5	5		5
Soybean oil meal	5	5		5
Mineralized calcite flour	1	1	1	1
Dicalcium phosphate	1	1	1	1
Salt	1	1	1	1
Flaked corn			10	
Crimped oats		22	15	
Flaked barley		5	5	
Linseed meal pellets			5	
Soybean oil meal pellets			5	
Distillers' grains		3		
Wheat bran		10		
Molasses	10	10	10	10
Total	100	100	100	100

Pelleted (Coarse) — Pelleted (Very Coarse)

All four mixtures were made from the same original lots of ingredients according to the same basic formula. For this reason they had practically the same chemical composition. Enough of the concentrates were mixed at one time to carry through the whole experiment which lasted about four months. Mow-cured hay was fed as the roughage part of the ration. Each animal received 12 lbs. of concentrates and 8 lbs. of hay daily.

In this experiment it also was possible to compare the relative nutritive values of each concentrate mixture with each animal. The sixteen complete digestion and utilization experiments were carried out according to the schedule below:

Period	Fine	Coarse	Very Coarse	Pellets
1	Cow 1	Cow 4	Cow 2	Cow 3
2	Cow 2	Cow 3	Cow 4	Cow 1
3	Cow 4	Cow 1	Cow 3	Cow 2
4	Cow 3	Cow 2	Cow 1	Cow 4

Feed Consumption Experiment 1952-53

Twelve milking cows representing the Ayrshire, Guernsey, Holstein, and Jersey breeds were used in an experiment to study the relative consumption of coarse and fine feeds. They were paired within breeds according to weight and stage of lactation. The experiment was divided into three five-week periods in order that a double reversal in grain feeding could be achieved. Random selection was used to determine which cow of each pair would receive the coarse feed and which the fine during the first period. At the end of five weeks the cows were changed abruptly to the opposite textured grain and at the end of another five weeks they were changed back to their original textured grain. The coarse and fine feeds were made from the same lots of ingredients and differed only in texture. They were mixed fresh for each period according to the coarse and fine formulae given in Table 1.

All cows received their grain at the same time, just prior to milking. The refuse was weighed back at the end of one hour. The amount fed each cow was such that no less than one pound would be refused. The cows were fed all the roughage they would consume. This consisted of a morning feed of first-cutting red clover hay and an afternoon feed of third-cutting red clover silage. Having the cows filled up with good quality roughage was an important factor in emphasizing differences in their desire or ability to consume the two types of concentrates. Records were kept of feed consumption, body weight, and milk and fat production.

Digestion and Utilization Experiment 1954

Despite the evidence reported both from this Station and elsewhere that there is no important advantage in feeding coarse-textured feeds over comparable high quality ones of the ground type and that coarse-textured feeds are nutritionally inferior to comparable ground feeds, the coarse-textured feeds still continue to be popular with many dairymen. Mindful of this popularity, it was decided to find out if there are any ingredients which can be used in the mixture in the coarse form without affecting the nutritive value adversely. Because of their importance both as a source of nutrients and also as a source of coarseness, corn and oats were chosen to be fed to the animals in both the fine and coarse forms.

Twenty-six complete digestion and utilization experiments were carried out using procedures similar to those outlined above. Five heifers 20-24 months of age were used as experimental subjects. The corn studied all came from one lot. Part was steamed and flaked by a large corn processor; the remainder was ground by means of a hammer mill. Two lots of oats were studied, part of each being steamed and crimped by a local feed man-

ufacturer, the remainder being ground by means of a hammer mill in the same feed mill. Field-cured hay was fed as the roughage. It was from a lot that had been evaluated previously with the same heifers receiving it as the sole ration. Each animal received 6.5-8 lbs. of corn or oats and 5-6 lbs. of hay depending on animal size. It was possible, as in the previous texture experiments, to make a comparison of the relative nutritive value of each ration with each animal. The schedule of the experiments was as follows:

Heifer	1st Balance	2nd Balance	3rd Balance	4th Balance	5th Balance	6th Balance	7th Balance
1	Hay	Crimped oats	Ground oats	Flaked corn	Ground corn	Ground oats	Crimped oats
2	Hay	Crimped oats	Ground oats	Flaked corn	Ground corn	Ground oats	Crimped oats
3	Hay	Ground oats	Crimped oats	Ground corn	Flaked corn	Crimped oats	Ground oats
4	Hay			Ground corn	Flaked corn	Crimped oats	Ground oats

Results and Discussion

In all experiments a fairly liberal allowance of concentrates in proportion to hay was fed to the experimental animals in order to bring out differences in digestibility and utilization due to differences in the texture of the concentrates. The level of feeding in each experiment was established by the amount of feed eaten by the poorest feeder among the experimental animals. In all cases the animals cleaned up their feed during the collection periods.

The average digestion coefficients and daily balances of protein and energy of the mixed feeds are shown in Tables 2 and 3. A statistical analysis of the data from the 1951 experiment showed that the fine feed excelled the coarse in every respect. In the 1952-53 experiment, with one exception, the fine textured grain mixture excelled the coarse, the very coarse, and the pellets in both digestibility and utilization of both the protein and the energy of the rations. The one exception was that the fine mixture and the pellets gave essentially the same energy balance. The coarse feeds and the pellets had essentially the same nutritive value. When expressed in terms of digestible protein and total digestible nutrients as shown in Tables 2 and 3, the fine mixtures were still superior in nutritive value to the comparable coarse feeds.

In the 1954 experiments on individual ingredients the animals did not clean up the ground oats as readily as they did the crimped. The ground oats seemed to lump when it came in contact with saliva, both in the animals' mouths and in that which drooled into the feed boxes. The ground corn, however, was cleaned up as readily as was the flaked corn.

The average digestion coefficients of all the feed constituents of the ground corn excelled the digestion coefficients of the flaked corn as seen in Table 4. The differences were significant at better than the 5 percent level. The ground corn excelled also in daily balance of protein and energy and gave higher values for digestible protein and total digestible nutrients, but these differences were not quite significant at the 5 percent level.

In the case of the oats essentially the reverse was true. The nutritive value of the crimped oats was generally superior to that of the ground oats. With the exception of the digestion coefficients of protein and ether extract

Table 2. Average Digestibilities, Balances, and Digestible Nutrients of Various Feed Constituents in 1951 Experiment

		Timothy Hay	Ground Grain	Coarse Grain
Digestion coefficients				
Dry matter	%	60.58	69.59	63.95
Protein	%	46.99	82.88	79.16
Energy	%	52.20	72.05	65.45
Ether extract	%	45.35	93.76	90.69
Fiber	%	62.99	33.59	19.78
Nitrogen-free extract	%	62.52	78.54	73.65
Metabolizability of energy	%	42.85	65.59	60.03
Daily balances				
Protein	g.		+231	+195
Energy	Cal.		+8449	+7241
Digestible nutrients				
Digestible protein	%	2.90	11.15	10.61
Total digestible nutrients	%	53.91	68.61	63.01

Table 3. Average Digestibilities, Balances, and Digestible Nutrients of Various Feed Constituents in 1952-53 Experiment

		Mow-cured Hay	Fine Grain	Coarse Grain	Very Coarse Grain	Pelleted Grain
Digestion coefficients						
Dry matter	%	66.74	73.17	70.45	70.85	70.85
Protein	%	63.45	74.64	69.68	70.89	70.15
Energy	%	60.49	73.63	69.17	69.78	70.44
Ether extract	%	10.41	91.49	91.22	89.06	89.82
Fiber	%	72.14	36.24	19.76	19.65	25.34
Nitrogen-free extract	%	67.82	80.06	77.59	77.65	78.29
Metabolizability of energy	%	50.64	67.60	63.08	63.76	64.67
Daily balances						
Protein	g.		+209	+148	+160	+152
Energy	Cal.		+6922	+6148	+5712	+6937
Digestible nutrients						
Digestible protein	%	6.83	12.74	11.29	11.54	11.45
Total digestible nutrients	%	59.05	67.91	63.48	65.29	65.81

Table 4. Average Digestibilities, Balances, and Digestible Nutrients of Various Feed Constituents in 1954 Experiment

		Field-cured Hay	Ground Oats	Crimped Oats	Ground Corn	Flaked Corn
Digestion coefficients						
Dry matter	%	57.15	58.86	61.35	75.52	69.21
Protein	%	54.73	72.39	72.40	46.95	44.17
Energy	%	47.63	54.23	60.21	64.24	61.87
Ether extract	%	28.07	94.98	94.56	90.00	88.33
Fiber	%	61.00	0	0	0	0
Nitrogen-free extract	%	57.67	71.21	73.52	83.09	73.63
Metabolizability of energy	%	39.84	50.70	55.30	59.91	56.69
Daily balances						
Protein	g.		+121	+151	+119	+88
Energy	Cal.		+3152	+4148	+3512	+3381
Digestible nutrients						
Digestible protein	%	4.29	8.81	9.63	4.33	4.13
Total digestible nutrients	%	55.63	67.82	70.58	82.20	78.16

which were essentially the same in both textures of the oats, the differences were significant at better than the 5 percent level in favor of the crimped oats.

The experiment conducted in 1952-53 to measure the relative feed consumption, milk and fat production, and gains in body weight of cows fed coarse and fine concentrates is summerized in Table 5. The data show that the difference in consumption of the coarse and fine concentrate mixtures

Table 5. Average Daily Feed Consumption, Milk and Fat Production, and Total Gains in Body Weight of Cows While Receiving Coarse and Fine Feeds

	Period 1	Period 2	Period 3	Average
Feed consumption				
Coarse concentrate	16.9	15.0	20.0	17.3
Hay	9.3	9.1	8.0	8.8
Silage	30.9	28.0	17.3	25.4
Fine concentrate	15.5	14.2	20.1	16.6
Hay	9.8	9.7	8.1	9.1
Silage	32.2	28.2	19.8	26.8
Milk and fat production				
Coarse	26.6-1.2	23.3-1.1	21.1-1.0	23.7-1.1
Fine	26.5-1.2	23.8-1.1	21.2-1.0	23.8-1.1
Gain in body weight				
Coarse	121	122	317	560*
Fine	150	238	302	690*

* Total

was not statistically significant. There was, however, a significant difference in the consumption between periods. Because the concentrates were mixed fresh for each period, it would seem that the difference between mixes was a more important factor affecting consumption than was texture. Although the cows consumed slightly more hay and silage with the fine grain than with the coarse, the difference was not significant.

The milk and fat production were relatively low because cows in late lactation were used with the hope that they would be more critical of the feed they ate. The difference in milk production was not significant. It also can be seen that grain texture had no effect on either fat test or fat production. Although the cows consumed no more feed and produced no less milk or butterfat on the fine grain mixture, they did gain significantly more in body weight than on the coarse mixture. This can be explained by the higher digestibility and utilization of the fine textured mixture.

Summary and Conclusions

THIRTY-TWO complete digestion and utilization experiments to study the effects of texture on the nutritive value of dairy grain mixtures were carried out with dairy cows and heifers over a period of three years. Twenty-six similar experiments were carried out to determine the effect of texture of both corn and oats on digestibility and utilization of nutrients. The concentrate mixtures studied were fine-textured, coarse-textured, very coarse-textured and pelleted. The corn was in the ground and flaked forms while the oats were in the ground and crimped forms.

The results of these experiments showed that the so-called fine mixtures were superior to comparable coarse textured and pelleted feeds in digestible protein and in total digestible nutrients. The coarse, the very coarse, and the pelleted feeds were essentially equal in nutritive value. In the experiment with the single ingredients the ground corn had a higher nutritive value than the flaked corn but crimped oats were superior to ground oats with the exception of the digestion coefficients of the protein and ether extract which were essentially the same in both textures.

Twelve cows representing the Ayrshire, Guernsey, Holstein, and Jersey breeds were used in a three five-week period double reversal experiment to determine the relative consumption of fine and coarse concentrate mixtures. The experiment showed that there was not a significant difference in grain or roughage consumption or in milk or fat production between the cows getting the two types of feeds. The animals which received the fine textured feed, however, increased significantly more in body weight, due apparently to greater digestibility of the fine grain.

It is concluded from these experiments that such so-called "fine" feeds as used in these studies are superior from a nutritive standpoint to comparable coarse feeds. Although practical experience indicates that while coarse feeds are consumed more rapidly under certain conditions than fine feeds, cows will normally eat adequate amounts of fine feeds if they are made from high quality ingredients. The work on individual ingredients indicates that crimped oats may be incorporated into a dairy feed to give coarseness without imparing its nutritive value.

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